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(54) Title: SMART BALANCING SYSTEM (57) Abstract This invention is related to a smart balancing system, where it determines the steady or varying imbalance force vectors acting on rotational drum or rotors, while rotating at high speeds and counterbalances the said imbalance force vectors by using one or more "balancing drums" fitted onto the same drum or rotor along the same rotational axis and one of the areas where such a balancing system used, being high speed spinning washing machines, where the imbalance force vectors acting on the system while spinning at high speeds are eliminated by the use of said intelligent balancing system.		

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SMART BALANCING SYSTEM

A rotor, drum or similar system, rotating along one axis is usually a very important part of many machines. Such similar rotational parts exists in electric
5 motors, various mills, fans, turbines, grinding machines, washing machines and many similar machines. In many machines, the balance is provided by adjusting the uniformity of the weight distribution of these rotational bodies along their rotational axis during manufacturing, where otherwise such an unbalance may cause unwanted vibrations in the machine which can even cause damage. But in
10 some cases, the rotating part of the machine can be under the influence of varying imbalance forces. A washing machine spinning at high speeds, a grinding machine with worn out grind stone, a mill with unevenly worn parts are some examples of such machines. The said invention of the smart balancing system brings effective solution for such imbalance problems faced in these machines. A washing
15 machine is chosen as an example in order to explain the said invention. The application of this invention for other machines will be similar to various washing machine types described below and therefore not explained in detail in this description.

20 In our present time, automatic washing machines are in use at homes, touristic locations, hospitals, residence homes, military organisations, organisations which provide professional cleaning services and many other areas. Besides the use of these machines for cleaning purposes, the use of such machines are continuously increasing in the textile industry for garment washing, stone washing and garment
25 dying processes. Due to increasing capacities in the cleaning and textile industries, the number of machines to be used per unit area tends to increase and this encourages the washing machine manufacturers to design and manufacture larger capacity machines. Larger machines mean larger front loading doors and larger diameter wash drums. The larger diameter drums, spinning at high speeds creates
30 new problems to be solved. Today, various washing machines are produced

ranging from 4 - 6 Kg used in our homes, 6 - 150 Kg used in professional cleaning services and 100 - 500 Kg used in textile industry which are bedded with shafts either from one end or both ends of the rotating drum.

- 5 In rotary drum washing machines, high spin speeds are usually required in order to achieve efficient spinning results at around 300 - 400g centrifugal forces. The factors which affect water extraction from garments in centrifugal spinning method are; drum diameter, drum rotation speed, the permeability and the temperature of the garments and the thickness of garments on the perforated
- 10 surface of the drum. Efficiency in extracting water is not directly proportional with the increased centrifugal forces due to higher drum rotation speeds. Increasing centrifugal forces, on one hand, forces the mass of water towards the drum circumference but at the same time, it squeezes all the garments along the drum's inner surface and these wet textile fibres under this force forms a plastic
- 15 type layer causing resistance against extracted water. It is more efficient to increase the inner drum surface area as this will reduce the garment thickness along the drum surface, causing better extraction. Increasing the inner drum surface usually results in deeper drum depths over longer rotational axis. The increased drum length makes it more difficult for the garments to be equally
- 20 distributed against the inner drum surface which causes high imbalance along the rotational axis of the drum. Even if this is achieved, very small differences in weight distribution along the rotational axis causes damaging vibrations at high spin speeds. This imbalance problem is the major design criteria in high spin speed washing machines. Today's classic systems employs techniques where the
- 25 drum assembly is placed on springs or air cushions and uses air or hydraulic type pressurised cylinders or shock absorbers in order to minimise the effects of vibration on the main body structure.

- Another method of reducing the effects of vibration is to increase the weight of the
- 30 mass, under the effects of acting imbalance forces. As a result, the mass which the

imbalance forces has to move is increased, reducing the magnitude of vibration. This requires the use of additional weights on the total construction of the washing machine. These additional weights on the machine usually exceeds 50% of the normally required mechanical construction weight of the machine. Apart from
5 this, the bearings used in order to connect this heavy mass of rotating mechanism to the main body construction has to be chosen larger than it should be necessary due to the high vibrational forces caused by the imbalance of the rotational system.

10 The vibration absorption systems used on the existing machines have limited use. By this reason, the garments have to be distributed along the inner drum surface as good as possible before the extraction process. In order to achieve this, the drum rotation speed first has to be increased to a level where the centrifugal forces just start to overcome the earth's gravitational forces. During this constant rotational
15 speed or speed increase, the garments near to the inner surface of the drum sticks to the inner surface and starts to rotate together with the drum. As the garments, which cling to the drum as a result of the centrifugal forces starts to get pressed towards the inner surface, the cling diameter will be reduced gradually. When all the garments sticks to the inner surface and starts rotating with the drum, the
20 distribution is said to be completed. If the garment distribution is not achieved properly, the extraction process will halt during spin process due to unacceptable vibration levels of the machine and the distribution process will commence again. These "re-starts" cause loss of time and energy as well as reduction in the machine capacity.

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BACKGROUND OF THE INVENTION

Many balancing techniques have been developed so far for washing machines, in order to eliminate the unwanted imbalance forces. These are generally mechanical systems which make use of the acting imbalance forces. These systems introduced
30 some improvements in small capacity machines but due to their complex

construction, they required maintenance and increased the over all cost of the machine and therefore not widely used. The said mechanical balancing systems weren't also successfully applied for higher capacity industrial washing machines. U.S. 2,534,267 / 268 / 269, Kahn, U.S. 3,117,962, Starr's patents are some
5 examples for the said balancing systems. The U.S. 5,280,660 Pellerin-Gaulter patent, which is most similar to the said invention in theory, has benefited from the ribs inside the rotating drum and tried to eliminate the imbalance forces by forcing water into these ribs through separate channels. This method divides the 360° of drum circumference into three locations with 120° apart and forces the
10 correct amount of water into one or more ribs opposite to the imbalance force vector until this vector is eliminated. This balancing system has, to a great amount, solved the balancing problems in the larger industrial type washing machines and with the additional precautions, high speed spinning was achieved. But with this method, it was impossible to eliminate the balancing weights
15 completely. The generated imbalance vectors can be at different points along the drum axis and the magnitude and direction can also vary.

For drums with small depth/diameter ratio, the above mentioned method could provide satisfactory results but as the depth of the drum is increased, the imbalance becomes almost impossible to be compensated with the said method.
20 Besides, the dynamic movements of the balancing fluid in the ribs itself causes varying imbalance weights in the system. With this method, the rotational axis of the drum must be highly horizontal. If this condition is not satisfied, the balancing fluid in the ribs will tend to collect to one side along the rotational axis in the ribs and cause further imbalance which will be difficult to compensate. The best
25 method of balancing a rotational mass is to compensate the mass from both ends of its rotational axis. This way, an imbalance force vector formed along the rotational axis of the mass can be compensated with smaller counter-weights compared to its magnitude. Therefore, smaller counter-balance weights encountered at each end of the rotational axis can eliminate the imbalance of the
30 drum. This is the only way to balance the system precisely. The better way of

increasing the capacity of machines is to increase the depth/diameter ratio of the drum where such balancing problems of the said system is eliminated with the said method. The Pellerin-Gaulter balance system, in actual fact, utilises an older method of forcing balancing fluids into three separate equal volumes in the rotating drum independently through separate fluid canals and pipes. At present
5 day, many applications of this idea is used, differing only in the way of control systems and sensing methods. But in the said new invention, the balancing method, the design of the balancing drum/drums and the method of injecting the balancing fluids into the balancing drums differ from the others to a great extend.

10 The other systems require intelligent electronic control units which have to sense and calculate the direction and the magnitude of the imbalance vectors and determine the amount of balancing fluid to be forced into each particular rib. The cost of such control units will specially be significant for domestic type washing machines where competition and economics are at utmost importance. Another
15 disadvantage of this balancing system by utilising such volumes in the drum is the loss of useful volume within the drum. Water naturally collects within these volumes during normal washing process. The chemical concentration in washing water is important during washing process. The amount water filled into these volumes means less chemical concentration and more energy use if heating is
20 used. If the imbalance force vector is formed at such an angle so that the counter-balance weight has to lie in somewhere in between the two ribs, then balancing fluids have to be forced into both ribs. In this case, since the total resultant counter-balance force vector is the sum of the two force vectors of the two ribs in the opposite direction of the imbalance force vector, the magnitude of each of
25 these force vectors have to be larger than the imbalance vector to be eliminated. The worst case condition is when the imbalance force vector is in the same direction with one of the ribs. In this case the counter-balance weight has to be in between the opposite two ribs, therefore equal amount of balancing fluids has to be forced into these two ribs. The counter-balance weight vector in the opposite
30 direction of the imbalance force vector is half of the centrifugal force vector

created. Therefore, the amount of balancing fluid mass to be forced into each corresponding rib has to be equal in magnitude to the imbalance force vector. In fact, only the same amount of mass needed to be inserted on the opposite direction of the imbalance force vector in order to eliminate it. Vector sum balancing method used in the washing machines requires twice the volume needed, in order to eliminate the imbalance weights. The balancing system described in the said invention uses both vector summing and direct opposite force vector method, therefore requires at least 50% less volume compared to the existing systems. Another requirement of these balancing systems is to keep the total washing times at optimum levels. After the washing process, the washing or rinsing water within these balance cells has to be released completely. At spin speeds, the imbalance of the rotational system has to be eliminated at the shortest possible times and after the spin process, the used balancing fluids has to be disposed without coming in contact with the washed garments. The balancing method to be developed should allow construction of any required size machine and should also be able to eliminate any kind of imbalance force vectors within the system.

SUMMARY OF THE INVENTION

The said dynamic balance invention allows the construction of any required size machine. In domestic washing machines, due to economical reasons, the system functioning makes use of the dynamic movements initiated by the acting imbalance forces. But in the industrial type washing machines, the cost savings on the machine construction due to balancing systems makes it feasible to use computers and sophisticated sensing systems for precise balancing results.

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In the industrial washing machines, after the distribution process is completed, the balancing computing system starts monitoring the imbalance force vectors separately from both ends of the drum and determines the direction and the magnitude of the counter-balance force vectors to be created in the front and the rear dynamic balancing drums in order to eliminate the cause of imbalance in the

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system. Therefore the disorder of the weight distribution within the rotational system is eliminated and high rotational speeds will be possible without any problems.

- 5 On the load/unload side of the main drum, another cylindrical drum with a diameter greater or equal to the main drum is fitted. The name of this drum will be called as "balancing drum" here on, and only a small surface of the balancing drum is slotted open and it is divided into smaller cells or pockets of equal volume. The number of these cells/pockets can be increased according to the
- 10 acceptable level of balancing, required in the machine. A second balancing drum similar to the one fitted on the front side of the main wash drum is also fitted on the rear side. A water jet system is also fitted exactly opposite to the slotted open inlet of each balancing drum units at each end. The balancing function computer control system determines the magnitude and the direction of the counter-balance
- 15 weight to be created in each particular balancing drum and controls the balancing fluid injector valves in order to fill the correct amount of balancing fluid into particular balancing cells/pockets in the drum closer to the imbalance vectors to be
- eliminated by controlling the valves fitted on the pressurised balancing fluid pipes.
- The fluids entering the balancing cells/pockets will start to rotate together with the
- 20 drum under the effect of the centrifugal forces. Therefore it is possible to balance the rotating drum independently from front and rear ends. There are two different types of valves used in the fluid injecting system. The computer system first uses the larger capacity valve or valves in order to roughly create the required counter-balance weights in the opposite direction of the imbalance forces to be eliminated.
- 25 After reaching a lower level of balance, the smaller capacity valve or valves are used in order to complete the balancing action.

In case said invention is applied to the washing machines, there will be no need for extra weights used for reducing the effects of the imbalance forces on the

30 machine and therefore the need for the springs, shock absorbers, air cushions and

such similar systems will be reduced to a great extent. Also, since the high level of vibrations will not be acting any more, the need for over sized bearings, the drum shaft and the drum construction will be reduced and become more economical. As a result, the machine construction will be simpler and more economical than before.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal-sectional view in diagrammatic form of an industrial washing/extracting machine constructed in accordance with the present invention.

10 **FIG. 2** is a front view in partial cross-sectional view of a first type balancing drum in accordance with the present invention.

FIG. 3 is a longitudinal-sectional view in diagrammatic form of a first type balancing drum in accordance with the present invention.

15 **FIG. 4** is a front view in partial cross-sectional view of a second type balancing drum in accordance with the present invention.

FIG. 5 is a longitudinal-sectional view in diagrammatic form of a second type balancing drum in accordance with the present invention.

~~**FIG. 6**~~ is a longitudinal-sectional view in diagrammatic form of a domestic and laundry type washing/extracting machine constructed in accordance with the present invention.

FIG. 7 is a side view with partial cross-sectional view in diagrammatic form of an industrial washing/extracting machine as seen along broken lines first A-A to reveal inner drum and second B-B to reveal sectional view of the inner drum and front side balancing drum.

25 **FIG. 8** is a side view of the special balancing liquid flow valve cut away to reveal the inner components in accordance with the present invention.

FIG. 9 is a diagrammatic form side view of complete system of the special balancing fluid valve.

FIG. 10 is a longitudinal-sectional view in diagrammatic form of an horizontal axis double side bedded drum type industrial washing/extracting machine constructed in accordance with the present invention.

FIG. 11 is a longitudinal-sectional view in diagrammatic form of an vertical axis bottom side bedded drum type industrial extracting machine constructed in accordance with the present invention.

FIG. 12 is a side and front view of the main drive pulley at the back of the main drum shaft designed as balancing drum cut away to reveal the inner balancing compartments in accordance with the present invention.

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DESCRIPTION OF THE INVENTION

The said invention of dynamic balancing system can equally be used in washer extractor machines as well as in extraction machines alone. This system can be applied to washing machines with single shaft, bedded with bearings from one end of the main rotating drum and also to machines with two shafts bedded with bearings on both end of the main rotating drum.

The said system consists of two separate balancing drums, fitted on each side of a wash drum, having the same rotational axis (1) as the main wash drum (2) of the washing machine. In FIG.1, a washing machine's side cross sectional view is shown in detail, with one balancing drum (3) fitted on the loading door (4) end of the wash drum and another balancing drum (5) fitted onto the rear shaft (6) end of the same wash drum. The balancing drums can have different shapes provided that they are based on the same concept. The balance drums are divided into smaller individual balancing cells or pockets depending on the capacity of the machine and the accepted level of imbalance. In FIG.2 and FIG.4, two differently designed balancing drum application examples are shown. In FIG.2, a balancing drum is shown in detail where the balance cells or pockets are indicated with dashed lines on the facing front side, with all three sides (8a, 8b, 8c) closed, except the side (7)

facing the rotational axis of the drum and the fluid transfer between the cells or pockets is prevented by the separator plates (9) fitted vertically to the axis of rotation. The side cross sectional view of this balancing drum is shown in FIG. 3. A stationary fixed fluid injector (10a) is placed directly across the side facing the drum rotational axis is fed with pressurised water. One or more valves (11a, 12a) are fitted on this pressurised pipe, feeding this injector. The solid sides (8) apart from the one facing the rotation axis and the separator plates (9) form the balance cell or pocket. The example shown in FIG.2 is formed from 24 cells or pockets. The balancing drums, which are going to be mounted according to machines' particular design characteristics, can be constructed with straight sides, perpendicular (8a) to the rotation axis of the drum or it can be constructed with conical (8b) surfaces at an angle with the rotation axis or as well as no straight sides at all. In order to prevent unnecessary loss of volume in the outer drum housing, the sides of the balancing drum, as shown for rear balancing drum (5) in FIG.1, can be shaped to fit drum's coupling side (8b). The cell separator panels can be mounted either perpendicular or at an angle to the rotation axis. If the separator panels (9) are mounted perpendicular to the rotation axis as shown in FIG.2, then at the cell entrance open side, additional wings (13) with an angle towards the rotation direction has to be used. There are two reasons for additional angled wings or angled mounting of the separator panels. One reason is, while spinning at high speeds, the pressurised balancing fluid would not splash around when hits the cell wall and the other to be able to dispense the wash water or balancing fluid easily. If the said angled construction is avoided, the fluid pouring out of the cell or pocket during rotation of the drum may be filled into the next cell or pocket and it will be impossible to empty the water out of the balance cells or pockets. On the other hand, angled construction of the separator panels or use of additional angled wing plates will cause some of the water to be lifted above the rotation axis of the drum. From this point, the water dispensed from the cell or pocket will be carried out of the balancing drum's plane by use of conical side plates (8b), or if necessary, over the angled wings (14) fitted at the opposite side of

the cell entrance. To help disposing the water out of the balancing drum plane, an angled surface plate is also fitted at the open side of the balancing drum.

The other balance drum design has a simpler construction compared to the design described above. One such balancing drum (5) is shown in FIG. 1 mounted at the
5 shaft (6) end of the wash drum at the rear side. In FIG.4, a front view of the said balancing drum is shown with balance cells as dashed lines, and in FIG.5, a similar balancing drum mounted at the front end of the wash drum is shown. In the said balancing drum construction, the side (16), facing the drum rotation axis,
10 is also closed as compared to the previously described balancing drum system. The outer opening of the balancing drum is constructed as an open slotted circle like doughnut shape (17) all along the front side of the balancing drum. The balancing water is injected into the balance cells or pockets through this slotted opening and also the disposal of the water is made from the same place. The water
15 jets (10b) are placed opposite to the side of the balancing drum and the injected water under pressure enters the balance cell (18). The disposing of the balance water or the wash process water from these balance cells or pockets are achieved while cells are over horizontal level and therefore, the possibility of disposed water entering the adjacent cells does not exist.

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The simplest application of the said invention is shown for domestic type washing machines as shown in FIG.6. In this application, the balancing drums (19) to be mounted on the rear and front side of the wash drum (20) is specially designed and formed by dies which can be made from plastic or stainless steel. When the
25 balancing action starts, a water pump (21) pressurises and conditions the water to be injected into the balance cells or pockets. The on/off control mechanism controls the said injector valve (22) and the balance water which is connected to the flexibly moving body of the wash drum mechanism (25) connected to the main machine construction via flexible fixtures (26). The physical movements caused
30 by the imbalance forces on the flexible moving drum mechanism in the controlled

axis will trigger the control mechanism (23) of the injector valve. The pressurised balancing water through the mechanical valve (22) is injected into the balance cells through the water jet (10) placed very close to the balance drum openings. Provided that the mechanical valve controlled by the physical movements of the flexibly moving drum mechanism under the effect of the imbalance forces and the water injector jet are placed at the correct axis and angle, it will be possible to counter-balance the system at the required speed. As an example shown in FIG.6, the on/off control mechanism of the injector valve is placed in such a way that it will operate only when the imbalance movements are in 'y' axis. The valve will operate when the movements in the drum mechanism are in the positive direction of the 'y' axis and greater than zero or pre-determined magnitude. This situation shows the moment when the imbalance force which cause the system to move is in (+)y direction. In the figure, the (+)y direction movement of the drum mechanism is shown with an arrow (27). The water inject nozzle must be placed on the other side, that is to say in (-)y direction in order to be able to inject water in the cells directly opposite of the imbalance force vectors. When the imbalance movements in the drum mechanism in (+)y direction exceeds the accepted level of movement, the valve will open (o) and when it is below, the valve will close (c). In this way, the counter-balance weight is formed by injecting balancing fluid to the opposite direction of the imbalance force vectors which moves the drum mechanism. As the imbalance force is reduced, the magnitude of movements will start to reduce and the time for the valve to stay open will start to reduce and as a result, the number of cells filling with balance fluid will be reduced. When the imbalance force vector magnitude approaches the accepted limits, the open duration of the valve will be so small that only the cell directly opposite to the imbalance force vector will receive balancing fluid. The water injection into the cells will stop completely when the imbalance forces are below the accepted level of the machine because the movements will not be sufficient to trigger the valve mechanism. The above mentioned balancing method starts operating after the garments are distributed in the wash drum and lasted while the drum speed is

controlled over a set period. Thus, while water is extracted from the garments in the drum, the balancing system will be active in order to compensate for the imbalance forces created.

- 5 As the capacity of the washing machines are increased, the systems employed for sensing and controlling of the balance action should become more accurate and work more efficiently.

As large capacity washer / extractor machines require a computer controller and related peripheral units in order to control the intelligent balancing system, the smaller machines between 2 to 25Kg. capacities other means of control devices can be employed. One example of such simple control system is to control the fluid injector from a mechanism which is directly connected to the drum mechanism as described above. Another way of controlling the balancing system based on the same concept is to sense the movements of the drum assembly caused by the imbalance force vectors by means of special level switches, magnetic or hall effect switches or optical sensors and control the balancing fluid injection by solenoid valves through electrical signals. In this kind of machines, the balancing function is carried out at constant speeds depending on the diameter of the wash drum and the capacity of the machine. After distributing the load within the drum, the machine's control system increases the speed of the drum to a predetermined speed level and keeps the rotation speed constant. The injecting nozzle location is calculated and placed accurately in the way of imbalance force movement direction, depending on the angular difference of the trigger mechanism and the counter-balance weight direction and also compensated for the over-all system delays. If only one balancing drum is used, one trigger switch, correctly positioned according to the nozzle position is placed on the balancing drum front side of the machine where the contacts will be able to operate with the physical movements of the drum mechanism. The switch contacts directly controls the valves for the injectors. Therefore the movements of imbalance forces become

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direct control signals of the injector valve. The system operates as follows if we ignore the time delays; The drum mechanism follows a sinusoidal movement pattern due to the imbalance forces. When the imbalance force direction is directly opposite of the trigger switch, the drum sinusoidal movement is at its peak point.

5 Therefore the water injector must be directly opposite of the trigger switch position. The switch mechanism has a spring actuator between the drum mechanism and the switch itself in order to absorb long strokes of the drum mechanism. Therefore the switch mechanism can be adjusted very close to the drum assembly. When the rotation speed of the drum reaches the required spin

10 speed, the drum mechanism will start to move depending on the magnitude of the imbalance force vectors acting on the system. As the pattern of movement sweeps the direction of the control switch, it will trigger the injector valve depending on the distance from the drum mechanism and start to inject balancing fluid starting from that position. As the peak sinus movement is over, the drum starts moving

15 away from the trigger switch and at one point the switch is completely released and the injector valve will be switched off completely. As the imbalance of the system is reduced, the magnitude of the sinusoidal movements will be reduced in proportion and the duration of the injector valve to stay "on" will also be reduced and this will cause less number of balance cells to be filled. As a result of this, the

20 imbalance force will be reduced to a limit where it will not be able to trigger the control switch and the balancing function is completed. In this case the drum speed can be increased to the required level without any problem. In smaller capacity machines, one balancing drum fitted on one side of the wash drum may be sufficient while larger capacity machines require two balance drums along the

25 rotational axis of the drum. The rib volumes in the wash drum of the washing machines can be connected together with the above said balancing drums to form counter-balance volumes. In this kind of application, if one balance drum is used, then the number of balance cells in the balance drum should either be equal to the number of ribs in the wash drum or twice as many. If the number is equal, then the

30 ribs should lie in the middle of each balance cell. If required, the ribs can be

divided into two equal volumes along their length and each volume of the rib can be connected to an individual balance cell. This way, economy can be achieved in small machines where precise balancing is not required. In the same way, when two balancing drums are used, the ribs can be divided into two volumes as required across their length and can be connected with corresponding balance cell
5 from front and rear of the drum. If this system is applied to the above mentioned ribs divided along their axis, they will be divided into four volumes, two sections across and another two sections along their axis.

10 The drum structure (28) which carries the drum beds is connected to the main body structure (29) via vibration absorbing materials like springs, air cushions or rubber blocks and even with flexible metal connections. FIG.7 shows a washing machine drum construction on air bellows in drawing A-A and the cross section details of the drum in drawing B-B. As a result of flexible connection of the drum
15 to the main body structure, the drum assembly follows sinusoidal physical movements due to the imbalance forces. The drum structure assembly (28), where the wash drum (2), and the drum housing (31) are connected with the system of a shaft (6) and the shaft bed (33), is connected to the main machine body structure with four movement sensors, like accelerometers, or sensors (32a, 32b, 32c, 32d)
20 made for similar purposes with two in front and two in the rear of the drum structure assembly, determines the movements of this mass in two separate movement axis perpendicular to the rotational axis. These two axis are chosen as perpendicular to each other, thus, the movement information on two separate axis at the front and the rear of the drum structure assembly is fed to the computer and
25 the magnitude and the direction of the acting imbalance force vector can then be determined.

In the control mechanism of the above mentioned balancing system, sensors (32a, 32b, 32c, 32d) are used to determine the vibrations and the movements caused by
30 the imbalance force vectors on the machine. The spin process starts after the wash

process is completed in the washing machine. At the end of wash process, the waste water in the machine is released through the drain system (82) shown in FIG.1, and after distribution process, while increasing the drum speed, the connected sensors monitor the vibration of the system and continuously checks
5 that the magnitude of the movements are below the predetermined signal levels. Another set of sensors in the balancing system, inductive, capacitive or optical, determines the speed of the wash drum together with an index reference point, and together with the signals from imbalance movement sensors, the magnitude and the direction of weight disturbance is calculated as a vector unit. If necessary, an
10 incremental or absolute encoder, connected to the main drum shaft via trigger belt or chain helps determine the position of the wash drum.

Each machine has its own varying natural resonant frequency. It becomes more efficient when the balance control is activated at different speeds of resonance
15 where the magnitude of movements are at maximum. The acceptable imbalance levels during operation of the machine are pre-programmed into the control unit and if the signals from the sensors increases above these acceptable levels, the control unit starts to inject balancing fluids into the balance cells or pockets directly opposite to the calculated imbalance force vector and this action continues
20 until the detected imbalance force vector is eliminated. Since the balancing drums are connected directly to the main wash drum, with reference to the determined angle of the imbalance force vector, the amount of counter-balance weight is determined in angle and magnitude and the optimum distribution of this counter-balance weight along the balance cells are calculated. The computer unit which
25 controls the balancing process continuously monitors all the variables which can effect this process (these are the mechanical delays, temperature and pressure, the over-all system weight or the tare weights). When the balancing process starts, the control unit injects a controlled amount of balancing fluid to a controlled position in the balance drums and checks the effect of these variables on the said process
30 and if the result of this diagnostic test is valid, then the system constants are

- accepted as correct and these parameters will be used until the next balancing process starts. If these results are not valid in the next diagnostic test, the control system accepts a disturbance in the system variables and starts to test the peripheral units and the mechanical parts as well as the system variables. If the
- 5 detected disturbance can be eliminated or compensated by the computer system, then this eliminated problem is given to the operator as an information but if the problem insists, then the control unit warns the operator and gives information about the existing problem on the display in order to reduce the maintenance time.
- 10 If the control system determines that the balancing process is progressing according to the predetermined conditions, the drum speed is slowly increased to a level programmed before-hand and at the same time monitors the signals received from the sensors. If the balancing fluid is injected at the correct position then the magnitude of the imbalance vector should be decreasing gradually and the control
- 15 system monitors this. The balancing process continues until the magnitude of the imbalance forces are reduced below the maximum permissible level of the machine and when this point is reached, the normal spinning process continues, but if during the balancing process period, the monitored levels of imbalance do not drop below the initial values, the control system decides that there is a fault in
- 20 the system and warns the operator before shutting the machine down.

The balancing fluid injectors (10a, 10b) are placed as near to the balancing drum as possible. Depending on the determined angle and magnitude of the imbalance force vector, the correct amount of balancing fluid is injected in bursts through the

25 fluid injector (11) or injectors (11, 12) under the control of the balance control unit. The variance of balance during the balancing process period is monitored by the control unit via the signals from the sensors. Therefore, the movements of the drum at each end of the drum's rotation axis is caused by the imbalance force vectors are monitored by the control unit. The direction of the imbalance force

30 vector detected by the sensors may not be at the same angle compared with the

position of the injector nozzle therefore, the control unit calculates the angle difference to be compensated. This angle difference is then transposed to a certain time delay by the computer unit depending on the speed of rotation. As an example, if an imbalance vector is detected on one end of the drum at an angle of 0°, then the correct position of the balance cell where the counter-balance weight should be added is 180° out of phase. But the position of the injector nozzle is at 90°. Therefore the balance water has to be injected with a delay of 90°. If we assume that the rotation speed of the drum is at 100rpm during the balancing process, the period of one rotation is 600ms and time delay reciprocal of 90° is equivalent to 150ms and this value is calculated by the control unit. If the balance drum has 24 balance cells, then the duration of the injector to stay open in order to inject into the correct cell is 25ms. In this case, the valve has to open with a delay of $150 - 12,5 = 137,5$ ms and has to stay open for 25ms. There will also be electrical, physical and mechanical delays from the instant of inject command and the fluid release from the nozzle. The computer unit has to take care of the said delay. The delay period is different for each system, but can also vary within the same system due to temperature and pressure fluctuations. The control system monitors the signals of sinusoidal movements of the drum structure caused by the imbalance forces. The control system operates the balancing process, a certain delay after the accepted vibration level of the machine is exceeded and will continue until a certain delay after the vibration level is reduced below the accepted level of the machine. The said delay time prior to balancing process is the sum of the calculated system delay time and the delay of the angular position between the sensor direction and the nozzle. The time delay of the angular difference is constant. The control system is programmed so that the delay time of the system can be determined by self calibration. The control unit determines this delay by measuring the response of the system to balancing action. Prior to self calibration, if the reduction in imbalance vector magnitude is monitored at constant angle difference, then the previous delay values are accepted to be

correct. If the angle difference is not constant in spite of reduction in imbalance magnitude, then the delay constant has to be re-calibrated.

The control unit starts the balancing process at a constant rotation speed by
5 monitoring the imbalance magnitude and direction at each end of the drum
rotation axis, after the garment distribution process is completed. Initially, the
rough balance has to be reached at the shortest possible time. For this purpose, the
larger valves (12) with higher flow rates are used and because of their longer
response times, balance fluids are injected into more than one balance cell in the
10 opposite direction of imbalance vector. In a balance drum with 24 balance cells
valve (11) is kept open long enough to inject balancing fluid into the balancing
drum so that, the half of the balance drum, opposite to the imbalance force vector
is filled with counter-balance weight to reduce the imbalance magnitude. By using
more than one balance cell for the counterbalance weight shortens the time needed
15 to reduce imbalance and also the balance cells are used more efficiently.
Therefore, a certain balance level is reached by injecting some balance fluid into
the necessary balance cells every drum rotation. As the reduction in imbalance is
increased, the number of cells are reduced where balance fluid is injected. During
the balance process, the control unit increases the speed of the drum within the
20 limits of the imbalance forces that the machine's mechanical construction can
withstand. As the speed is increased, the reaction of the remained imbalance will
tend to increase as well. Therefore the speed is increased under control while the
imbalance is reduced. After reaching a predetermined speed level, precise
balancing process starts using the valves (11) with less flow rate and quicker
25 response times. The response times of these valves are 6 - 8ms and the said classic
type solenoid valves are used for drum speeds up to 400rpm. When 400rpm drum
speed is reached, the said classic type solenoid valves cannot be used any longer
for balancing process due to their long response times of switching on and off. In
actual case, the wet textile in the drum, which needed to be balanced due to its
30 uneven distribution may not loose water proportional to its initial weight

distribution. In this case, balance compensation will be required during the balance process due to the loss of water from the textile. Two different methods can be used;

- 5 In the first method, when the magnitude of imbalance forces exceeds the allowable limits of the machine specifications, the speed of the drum can be reduced down to the speed where faster valves can compensate for the loss in balance and then increasing the speed to previous level.
- 10 In the second method, much faster valves can be used which will allow the control system to monitor and compensate for the loss of balance at higher drum speeds.

The mechanical valves connected to the drum body structure, suitable for use in domestic type washing machines as described before, can be utilised here in this case. Another special valve to operate in synchronism with the rotating drum and suitable for injecting balance fluids at high drum speeds is specially designed. (FIG.8) The valve's rotational cylindrical centre (35), which serves as the on/off control of the valve is directly connected to the drum shaft (6) via a trigger belt (36), a pulley (42) system as shown in FIG.8. As the speed of the drum is increased, the required periods for fluid injection has to be reduced and since the on period of the valve is shortened, this increases the resolution. The said valve consists of cylindrical outer body (39) and bedded (38) rotational inner drum (35) with a row of holes or a slot opening (37) perpendicular to its rotational axis. The outer cylindrical body has also holes or a slotted opening (40a, 40b) to match the holes on the inner drum. The inner drum of the valve rotates as directly connected to the main wash drum assembly and half the speed of the wash drum. In order to achieve speed reduction in the valve drum, the drive pulley (42) diameter of the valve is twice the size of the pulley (41) on the wash drum shaft. Because the holes in the inner drum opens and closes the valve twice every rotation, switching on, in the same period with the wash drum is provided. The ratio of the diameter

of the holes or the slot opening, to the circumference of the total inner drum of the valve is equal to $1/(\text{balance cell number}) \times 2$. Therefore, the time of opening of the valve when the the holes coincide is equal to the time of one cell to pass in front of the nozzle. The outer cylinder is also made to rotate by a stepper motor

5 (43) over 360° under the control of the computer control system. The outer cylinder movement of the valve can be achieved by a belt (44) and a pulley (45) as well as a chain or a directly coupled cogs. The system changes the position or angle of the outer cylinder and adjusts it according to the position of the balance cell to be filled. It also takes the system delays into consideration. When the outer

10 cylinder is in correct position, the solenoid (46) which allows the water into this valve is opened. The fluid with the pressure raised to 10 - 12 bars by a special pressurising system reaches to the correct balance cell every rotation of the drum, synchronised to the speed of the main drum. With this method, balance compensation can be provided at high drum speeds during spinning of the load.

15 One other method of injecting balancing fluid into the balance cells is to use separate water channels which is used in many balancing systems up to date. It is possible to transfer the injected fluid into the required balance cell with this method, through channels formed in circles, placed anywhere on the rotating system, with the rotation axis as the rotation axis of the drum. If individual water

20 channels are placed inside or outside of the drum housing, as many as the total number of balance cells in the front and the rear balance drums, then if a counter balance weight is required in a balance cell, it will be sufficient to inject fluid into the corresponding channel. The said channels are completely sealed apart from the sides facing their rotation axis and only connected with the balance cell that it is

25 related with. Therefore the fluid injected into these channels is forced to the outer surface, which is leak proof, due to the centrifugal force and goes into the balance cell that it is connected with.

The intelligent balancing system, apart from machines with single bedding from

30 one side of the drum, can also be used for machines with bedding from both sides

of the drum and where the garment load/unload is made through the openings on the curved sides of the wash drum. The balancing drum can be applied to both ends of the wash drum, as applied to one side as described above. In FIG.10, an application of the said system to a machine bedded on both ends of the drum is shown. The working principle of the system is the same as single side bedded drum principle.

Another application area of the intelligent balancing system is the vertical mounted extractor machines. The balancing is a serious problem on these machines too. Therefore the said invention is an important solution for these machines as well. Because these machines are mounted vertically, the placement of the balancing drums must differ from the machines that work on horizontal mounted drum axis. One important reason for the difference is to dispose the balancing fluid out of the balancing drum without wetting the garments, after the spinning process is completed. In FIG.11, an example of the said dynamic balancing system is shown as applied to the drum (49) of a vertically mounted extraction (high speed spinning) machine. The load/unload door (50) of the drum is facing up-wards. In case balancing drum is applied to the main drum, the balancing drum (47) must be mounted at the load/unload end of the drum. In this application, the balancing drum is not completely sealed with the wash drum as it was the case with washing machines. There is a slight gap (51) in between. The balancing water, which rotates together with the balancing drum due to the centrifugal forces during the balancing process, will slowly start to pour down the conical sides (52) of the balancing drum which is inclined downwards, as the drum starts slow down after spinning process and the earth's gravitational force starts to overcome the centrifugal forces, and from the main drum's conical surface (53) down the drum and empties the balancing drums. The balancing drum is connected to the main drum with fixtures (54) so as to leave a slight gap. While the said dynamic balancing system can be applied to smaller capacity extractors with one single balancing drum, the larger capacity extractor machines will

require two separate balancing drums to be fitted at each end of the main drum, because it becomes impossible to balance the system due to the formation of different imbalance force vectors along the rotational axis of the drum. In this case, the second balancing drum (55) is mounted at the bottom end of the main drum as to join the drum surface completely. It is much easier to empty the water out of this balance drum compared to the one fitted to the top of the drum. The only thing to do is to construct the lower surface of the balancing drum (57) slightly conical at the entrance of the drum slotting and as the drum speed is reduced, the balancing water will drain out over this conical surface. Apart from this, the balancing process is exactly the same as in the washing machines.

The balancing drums to be used in the washing machines can be made in many different shapes, using many different materials. The balancing drums for the domestic type washing machines can be produced from plastic specially moulded and fixed to the stainless steel washing drum or it could be shaped with a die out of stainless steel. As the machine capacities are increased, it becomes more difficult to apply single piece plastic or stainless steel forms using die casts. In this case, the balancing drum can be constructed from many separate pieces where each piece can be made from plastic or metal and then put together to form the balancing drum. Various plastic production techniques can be utilised for the production of the balance cells. Plastic cells or pockets can be produced by injection moulding, expansion, or plastic welding methods and metal cells or pockets can also be produced in order to form the balance drum.

Another application method of the balance system is to mount the balancing drums out of the wash drum housing. In machines where the drum assembly is bedded from one side, it is only possible to mount the balancing drum out of the drum housing at the shaft end, while in the machines where the drum is bedded from both ends, both of the balancing drums can be mounted out of the drum housing. As this method makes the machine's construction more difficult, the

required volume for these balancing drums in the drum housing is eliminated and therefore it will be economical in the long run, due to the reduction in water used and hence reduction in detergent and heating energy. Another advantage of this application is that, the required amount of counter balance weight to be used in the balancing cells at each end of the drum along the rotational axis is reduced as moved away from the location of the imbalance vector position. The shaft drive pulley is fitted at the far end of the drum shaft, and as the balancing drum can be mounted anywhere along this shaft, it can also become the drive pulley of the drum. In this case, the size of the balancing drum located at the far end of the drum shaft will be smaller than the balancing drum used in the drum housing at the shaft end.

FIG. 12, shows the use of the rear drive pulley (58) as a balancing drum. 24 balancing cells (59) are constructed in the drive pulley. The balance cells are constructed in the drive pulley by using separation plates perpendicular to the balance drum. While the balancing fluid is dispensed easily into the drum housing when the balancing drum is fitted in the drum housing as part of the drum, in the application where the balancing drum is part of the rear drive pulley, the back end of the pulley is closed with a lid (61) in order to dispense the balancing fluid without splashing, out of the system. A flange on the drive pulley (62) rotates in a channel in the said lid and prevents the water to leak out. The injector nozzle (10) mounted onto the stationary lid directly lies across the open ends of the balance cells. The water reached the lid is disposed through a drain pipe (63) out of the system. Since the said balance drum is out of the wash drum housing, another balance fluid can be used apart from water. In this case the system can be used as a closed system. The balancing fluid can be pumped from a tank and used for the balancing process and then this fluid can be transferred back to the tank for reuse. In this case one of the important fluids to be used as balancing fluid is the hydraulic system oils. It has many advantages apart from the disadvantage of having a lower density than 1 which means an increase in balance volumes but it

is possible to make use of many accessories for hydraulics. The flow rate of the balancing fluid during the balancing process is important for short balance times. It is very easy and economical to install such system outside the machine which makes use of hydraulic oil, high pressure hydraulic pumps, seals, and a large
5 choice of valves. Since the hydraulic is not corrosive, stainless steel and antirust materials are no longer required for system construction and this is economical. The balance system which can be adapted to the shafts, can be used for any kind of machines with bearing from one end or both ends with variable imbalance problems. All machines facing imbalance problems can be balanced with two
10 balancing drums placed properly on both sides of the rotating system and it is possible to compensate these vibrations by monitoring the vibration levels when necessary .

CLAIMS:

1- A machine with drum or rotor which rotates around its shaft axis which is mounted on to an outer body structure via shaft beds and/or suitable bearings,
5 comprising:

at least one balancing drum attached to the said rotating shaft/drum assembly or to the said rotational system and rotates together with it,

said each balancing drum has at least three balance cells with equal volume, the magnitude and the direction of the imbalance vectors acting on rotating
10 system is sensed during rotation of the drum by the use of suitable sensors mounted on the rotating system, where said rotating drum system is mounted flexibly on the main body structure,

said imbalance vectors acting on the rotational system is detected using one or more suitable sensing systems and the magnitude, direction and the position of
15 the imbalance vectors are then sensed and/or calculated,

this sensed and/or calculated imbalance vector is counteracted by injecting pressurised balancing fluids into the said balancing cells in the correct sensed or calculated positions,

the pressurised balancing fluid injector nozzle is positioned facing the
20 opening of the said balancing drum,

said balancing fluids are pressurised by suitable conditioning or pumping equipment and the injecting pattern is controlled precisely by one or more suitable valve/valves,

said machine is essentially under effect of variable imbalance forces due to
25 its nature of working conditions and principles.

2- A balancing drum in accordance with claim 1 wherein,

only the sides of the balancing cells facing to rotation axis are opened or slotted and all the other sides are closed and sealed,

wings as an extend of cell separators are fitted at the entrance of the cells with an angle with cell separator walls.

3- A balancing drum in accordance with claim 1 wherein,

5 all the sides of the said balancing drum are closed and sealed which only allows the balancing fluid entrance into the balancing cells through slots as a doughnut shape on the side of the balancing drum which is not used for mounting to the main drum or rotor.

10 4- A fluid injecting system in accordance with claim 1 wherein,

at least one balancing fluid injector system is used for each of the balancing drums,

at least one fluid flow control valve is used for each injector system on a pipe with a nozzle at the injecting end in order to accelerate the fluid flow rate,

15 said injector nozzle is fixed facing to the opened side of the balancing drum, the injector control valve(s) in the balancing system are precisely controlled in such a way that the required amount of balancing fluid is injected into the required position of the balancing drum during balancing operation.

20 5- A fluid injecting system in accordance with claim 1 wherein,

separate injector systems are used for each balancing cell and also for each of the balancing drums,

each said injector system means a narrow liquid canal in a ring form as its rotating axis is the same with drum rotating axis and only the sides of the ring
25 facing rotation axis are opened,

each of the said liquid canal is connected to one balancing cell by a proper connection system

injected liquid in the canal, pass through said connection system to enter the balancing cell by centrifugal force effect,

at least one injection control valve placed on the injecting system to control fluid flow injected in the rotating liquid canal,

6- A machine in accordance with claim 1 wherein,
5 the rotational drum housing structure is flexibly mounted to the main rigid body structure,
the position, magnitude and direction of the imbalance vectors are calculated by purpose built controllers by using the imbalance signals sensed by the fitted sensors,

10 it is a high speed centrifugal spinning machine, used for extracting fluids from the liquid absorbent goods, in which the sensed imbalance vectors are processed in a suitably programmed controller unit in order to calculate precisely the amount of counter-weight to be injected into the correct balancing cell of the balancing drum or drums to balance the system which rotates together.

15 7- A machine in accordance with claim 6 wherein,
it can also be considered as a washing machine used for textile and garment
— washing. —

20 8- A machine in accordance with claim 6 wherein,
it can also be considered as a dyeing machine in textile garment dyeing.

9- A machine in accordance with claim 6 wherein,
it can also be considered as a machine which can be used as a stone-wash
25 machine.

10- A machine in accordance with claim 6 wherein,
the rotational drum housing system flexibly supported by gas pressurised rubber bellows.

30

11- A machine in accordance with claim 6 wherein,
the rotational drum housing system flexibly supported by rubber or similar
flexible material blocks,

5 12- A machine in accordance with claim 6 wherein,
the rotational drum housing system flexibly supported by suspension springs
either hang by springs or placed on a platform supported by springs.

10 13- A machine in accordance with claim 6 wherein,
the rotational drum housing system flexibly supported by flexible or semi-
flexible metal, plastic or any similar synthetic coupling or fixing material.

14- A machine in accordance with claim 6 wherein,
the control system takes care of time delay characteristics of the system to
15 activate the required number of injector valves for counter weighing,
the control system continuously monitors the accepted and applying values
of the system time delays,

~~the system also use a reference point for said controlling on the drum
assembly,~~

20 said reference point is provided from a notch via a switch or sensor or an
encoder connected to the rotating shaft of the drum,

the balance control system checks and measures the angle between the
position of the imbalance vector and position of the reference point on the drum
system, before starting the balancing operation,

25 the control system continuously monitors the said pre-detected angle during
balancing operation,

the control system change the time delay constant used in calculations if any
deviation is recognised in the value of the said pre-detected angle.

30 15- An extraction machine in accordance with claim 6 wherein,

rotation axis of the drum is horizontal,
the balancing drum is mounted on the main rotating drum with the same rotational axis,
separator plates of the balancing cells placed in the direction of the
5 rotational axis as each cell having equal volume,
balancing drum/drums are placed in the drum housing so water can be chosen as balancing fluid.

16- A balancing drum in accordance with claim 15 wherein,
10 the number of the balancing cells equal to the number of ribs used in the main rotating drum and they are placed to connect each rib to the centre of the corresponding balance cell,
said balancing cells share same volume with the corresponding ribs as the balancing fluid injected in that particular cell can pass through into the
15 corresponding rib and vice-versa but sealed properly in order to prevent any leak from the ribs.

17- A balancing drum in accordance with claim 15 wherein,
ribs of the drum is divided into two equal parts along their mounting axis,
20 the number of balance cells are twice the number of ribs mounted in the rotating drum and they are constructed in such a way that the ribs of the drum are placed between two balancing cells using same separation plate with ribs and balancing cells,
the said balance cell share same volume with the corresponding rib
25 separation as the balancing fluid injected in that particular cell can pass through into the corresponding rib separation and vice-versa but sealed properly in order to prevent any leak from the ribs.

18- A method in accordance with claims 16 and 17, which is applied on a
30 drum with two balancing drums on both sides,

where said corresponding ribs are separated into different volumes by a separation plate in a direction across the rotation axis, in such a way that front balancing cells use front side volume of the ribs and the rare side balancing cells use rare volume of the ribs.

5

19- A drum in accordance with claim 15 is rotatably mounted about its axis to the main body structure with two bearing systems through the shaft from one side of the drum comprising,

only one balancing drum is mounted to the main rotating drum,

10 said balancing drum, placed near loading door side and one side is shaped in such a way that it exactly fits the shape of the main drum or mounted as to share one side of the drum as the side of the balancing drum.

20- A drum in accordance with claim 15 is rotatably mounted about its axis to the main body structure with two bearing systems through the shaft from one side of the drum comprising,

only one balancing drum is mounted to the main rotating drum,

15 said balancing drum placed shaft side and one side is shaped in such a way that it exactly fits the shape of the main drum to fix or mounted as to share one side of the drum as the side of the balancing drum.

20

21- A second balancing drum is attached to the drum in accordance with claims 19 and 20 wherein,

the second balancing drum is mounted on the opposite side of the first balancing drum on the main drum as explained in claim 19 and 20.

25

22- A second balancing drum is attached to the main drum in accordance with claims 19 wherein,

the second balancing drum is mounted on to the drum shaft about its rotating axis as placed outside the main drum housing within said shaft mounted from one side to the rotating drum also about its rotating axis,

5 said second balancing drum is rotatably mounted in a leak prevented outer housing drum in order to keep the balancing fluids in the system where said balancing drum housing is attached to the main drum housing assembly,

 said balancing drum housing has a suitable drain system in order to be able to drain the balancing fluids.

10 23- A drum in accordance with claim 15 is rotatably mounted with bearings through two separate shafts fitted from each side wherein,

 both balancing drums, fitted at each end of the rotating drum as placed inside the main drum housing.

15 24- A drum in accordance with claim 15 is rotatably mounted with bearings through two separate shafts fitted from each side wherein,

 both balancing drums, fitted at each side on the rotating drum shaft is placed outside the main drum housing,

20 both balancing drums have their own outer housing drum attached to the main body structure in order to keep the balancing fluids in the system,

 these balancing drum housings have their own suitable drain system in order to be able to drain the balancing fluids.

25 25- Balancing drums in accordance with claims 22 and 24 wherein, balancing drum fitted on the drum shaft as placed outside of the drum housing, also used as a drive pulley for the main rotating drum.

30 26- Hydraulic oil used as the balancing fluid in the balancing drums in accordance with claims 22 and 24, fitted on the drum shaft, placed outside of the drum housing.

27- An extraction machine in accordance with claim 6 wherein,
said rotating drum axis is vertically mounted,
balancing drum is fitted directly on to the main drum with the same
5 rotational axis,
said balancing drum is fitted at the upper side of the drum at the loading
door side,
there is enough gap between the balancing drum and the main drum unit
fitted in such a way that the balancing fluid can be released out,
10 said balancing drum side, facing the sides of the main drum is conical,
inclined in such a way that the balancing fluid move towards to the rotational axis
during release out,
said main drum side, facing the sides of the balancing drum is conical,
inclined in such a way that the balancing fluid move in a direction away from the
15 rotational axis towards to the outside of the drum.

28- An extractor machine in accordance with claim 27 wherein,
a second balancing drum is added,
said second balancing drum is fitted at the bottom end of the drum,
20 bottom side of the said balancing drum is conical, inclined in such a way
that the balancing fluid move towards to the rotational axis during release out.

29- A sensor fitted on the machine in accordance with claim 1 wherein,
used for sensing the axial movements and convert them to electrical signals,
25 according to piezoelectric principle,
piezoelectric sensor is bonded onto a specially treated flexible steel plate to
generate electrical signal currents,
one end of the said flexible steel plate assembly is mounted rigidly onto the
main body structure and the other end is connected to the flexibly moving
30 structure through a spring,

movements of the moveable structure causes proportional physical movements of the flexible steel plate and as a result piezoelectric sensor via used springs generates proportional electrical signals.

5 **30-** A sensor used in the machine in accordance with claim 1 means an accelerometer.

31- A sensor used in the machine in accordance with claim 1 means a mechanical or electromechanical switch wherein,

10 said switch is mounted onto the rigid body structure and the movements of the moveable structure is conveyed to this switch either by direct contact or through links by pulling or pushing of flexible structure like a spring system,
_____ applied electrical current to the said switch, converts to meaningful signals for the electrical and/or electronic control units of the system by switching
15 contacts on and off caused by the physical movements.

32- A switch in accordance with claim 31 wherein,

 said switch is positioned at such a place away from moving structure where the physical movements caused by the acceptable imbalance level of the rotational
20 drum structure will not come in physical contact with the switches and also positioned by taking into consideration of the injector nozzle position and all the system time delays,

 contacts of the switch is closed depending on the physical movements of the rotational drum assembly causes the corresponding balancing fluid injectors valve
25 to open with the electrical current through the switch,

 said injector valve means one or required amount of solenoid valves

 pressurised fluid injected by the balancing fluid control valve openings into the said balancing cells to form a counter weight in the balancing drum in such a way to balance the existing imbalance vector.

30

33- A balancing system in accordance with claim 4 wherein,
balancing fluid flow control valves used in the system means solenoid
valves,

the number of solenoid valves used in the system depends on the capacity of
5 the said machine,

these solenoid valves can be classified depending on their fluid flow rates
and also response time characteristics,

high flow rate and longer response time solenoid valves are used initially
during the balancing process in order to fill more balancing cells,

10 lower flow rate and shorter response time solenoid valves are used for fine
balancing process.

34- A valve used in the balancing system in accordance with claim 1

wherein,

15 said valve used controlling the balancing fluid flow in synchronism with the
rotating drum assembly also during high speed spinning which rotates with
rotating shaft of the drum assembly, via a transfer system,

the main-body-of-the-said-injector valve is constructed as solid cylindrical or
spherical shape rotatably mounted and bedded in a cylindrical or spherical shape
20 housing,

said cylindrical or spherical solid valve mechanism is connected to the main
drum shaft via a transfer mechanism with a transfer ratio of $\frac{1}{2}$,

shaft of the internal cylindrical or spherical main mechanism always rotates
at $\frac{1}{2}$ speed of the main drum shaft,

25 diametrical size of the balancing fluid flow slots or holes are equal to the
ratio of the circumference of the valve's rotating shaft divided by the number of
total compartments in the balancing drum to the number of compartments required
to fill,

there are matching slots or holes in the outer housing of the said valve
30 system to coincide with the slots or holes in the inner rotating shaft of the valve,

outer slots or holes of the said valve from outer housing are connected to the balancing fluid pressurising system from one side and fluid injection system from the other side,

outer cylindrical housing of the said special valve is controlled over 360°
5 with a stepper motor or similar position controlling system,

position of the outer cylindrical housing of the said valve is controlled depending on which balancing cells require to be injected with balancing fluid.

35- A machine includes an inner drum rotatably mounted about its rotation
10 axis to the outer main body structure by bedded bearings through a main shaft from one side of the drum which also to be used for extraction at high speed spinning means a washing machine comprising,

_____ a balancing drum is fitted onto the said rotating drum,

rotational drum assembly is mounted to the main machine body structure via
15 flexible fixtures so that the physical movements of the rotational drum due to imbalance forces can be transferred to the drum housing structure,

control mechanism of balancing fluid injector valve, mounted onto the main body structure, are directly connected to the drum housing assembly,

balancing fluid injector valves are activated as openings and closings
20 depending on the movements of the rotational drum assembly caused by the imbalance forces,

nozzle of the balancing fluid injector which injects balancing liquid as balancing load is positioned in the same angle with peak opening of the valve but at the opposite side of the drum ,

25 to inject liquid in correct position, the balancing fluid system is connected to a pressurised control unit,

said valve openings continue to fill equal amount of load to opposite balancing cells to counter-act the acting imbalance force vectors as long as they exist.

30

36- A washing machine in accordance with claim 35 wherein,
a second balancing drum, is added onto the rotational drum,
a second set of balancing fluid injector valves are mounted onto the main
body structure of the said machine,

5 said second balancing system works according to the same principles as in
claim 35,

37- A mill with a rotor in accordance with claim 1 wherein,
said imbalance problems on the machine, by using balancing drums in
10 accordance with claim 2 or 3 which are mounted on the shaft placed in an outer
drum housing,

 said main rotor body structure connected by methods in accordance with
claim 10, 11, 12, and 13,

 said imbalance problems on the machine sensed by methods in accordance
15 with claim 29, 30 and 31, and eliminated by forming counter balance weight in
the balancing drum by injecting balancing fluid into the required position of the
balancing drum during balancing operation.

38- A machine in accordance with claim 37 means a grinding machine with
20 a rotor.

39- A machine in accordance with claim 37 means a fan with a rotor.

40- A machine in accordance with claim 1 wherein,
25 balancing process is carried out at a constant drum speed periods,

41- A machine in accordance with claim 1 wherein,
balancing process is carried out while continuously accelerating or
decelerating the drum.

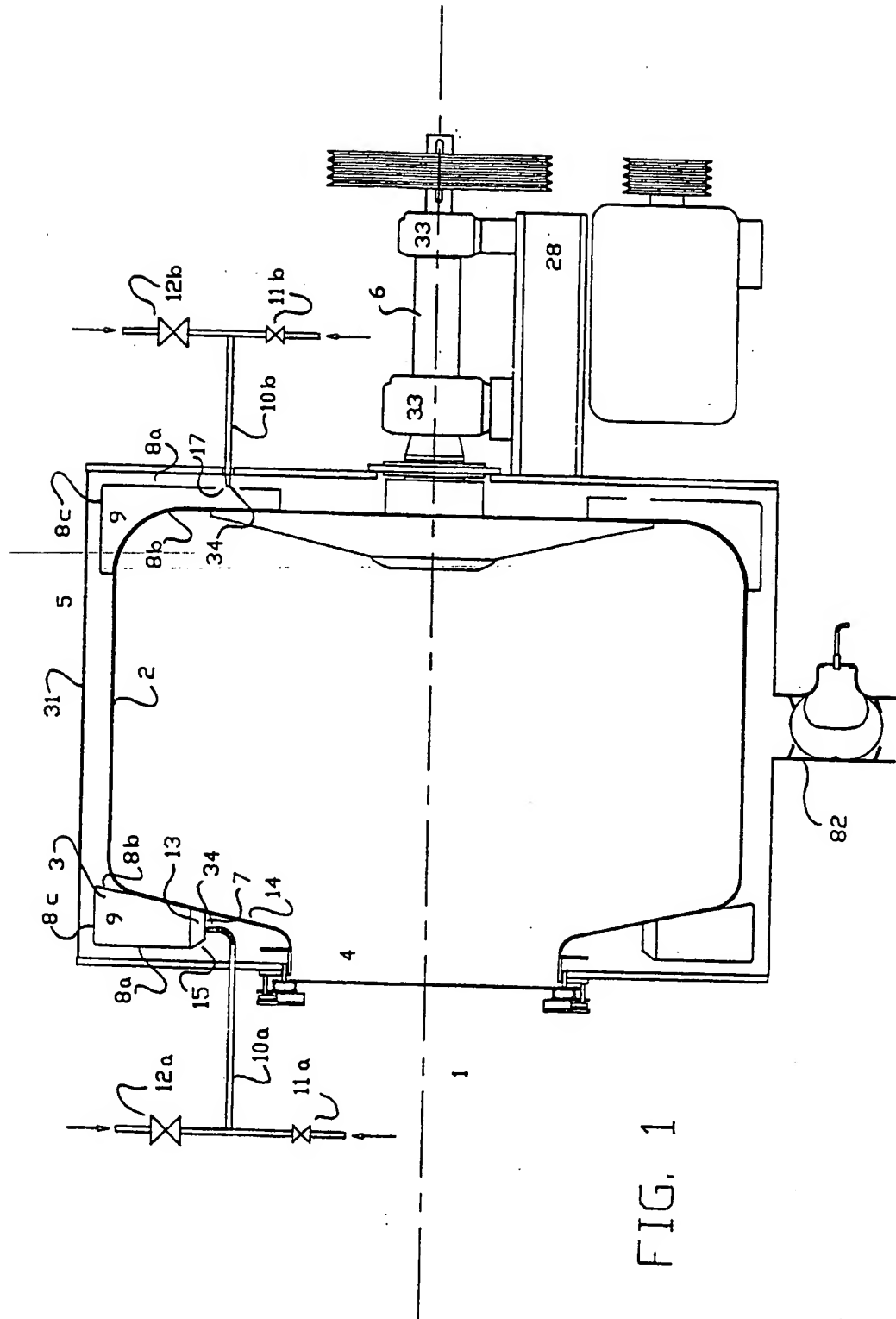


FIG. 1

FIG. 2

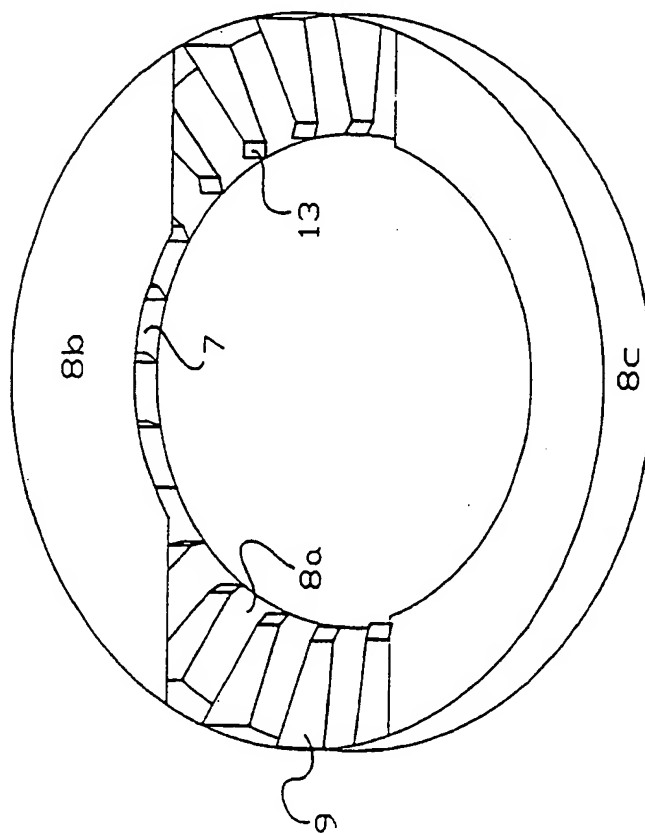


FIG. 3

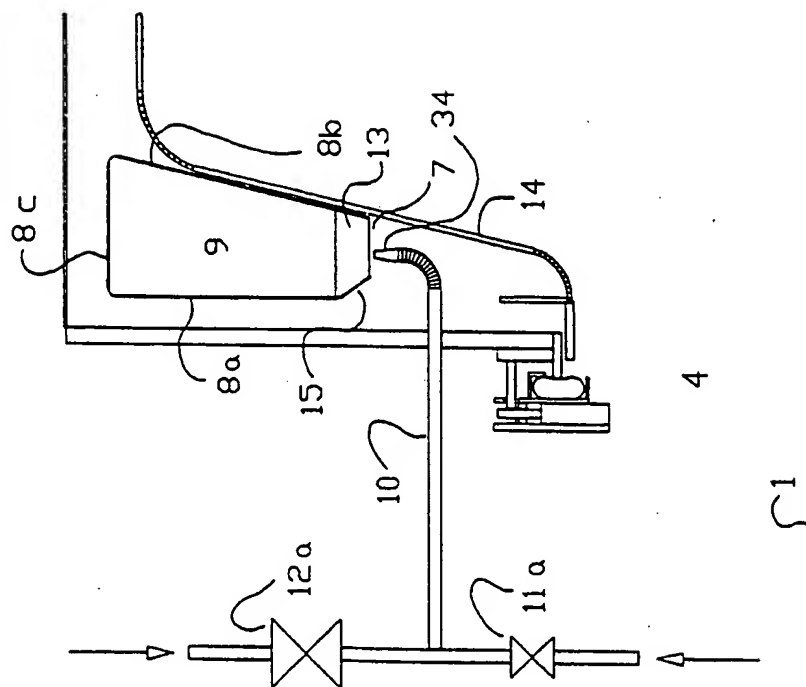


FIG. 4

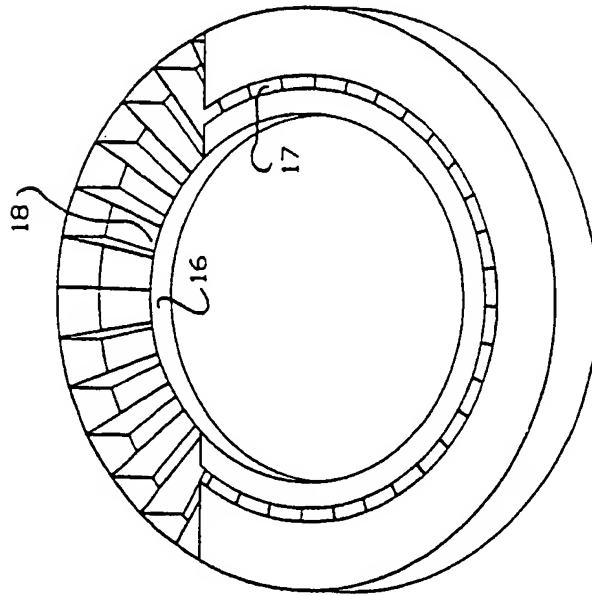
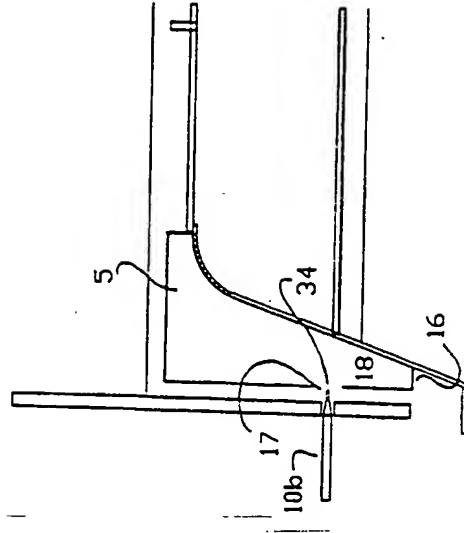


FIG. 5



17

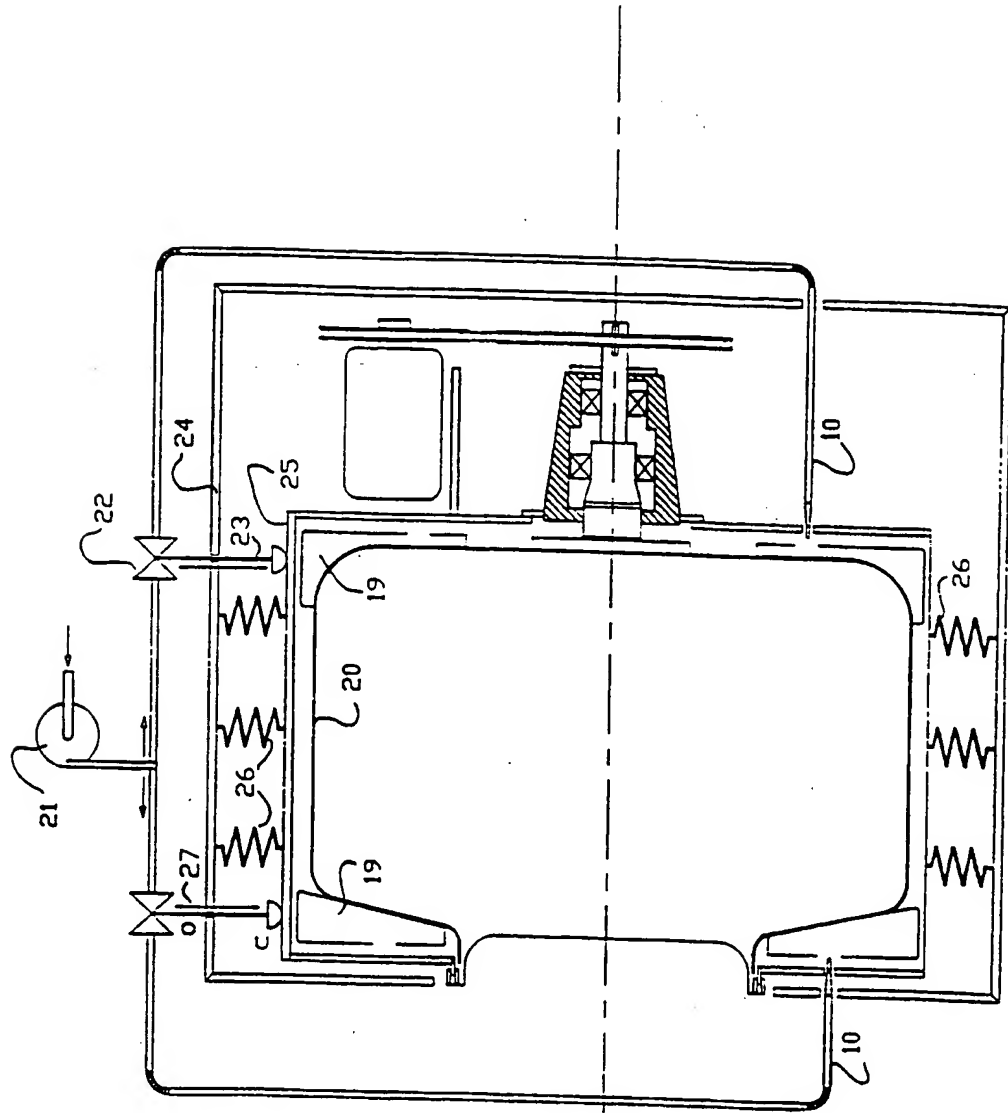
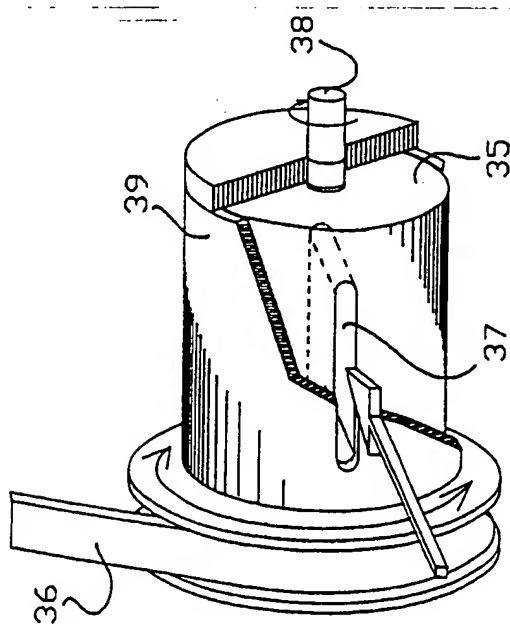
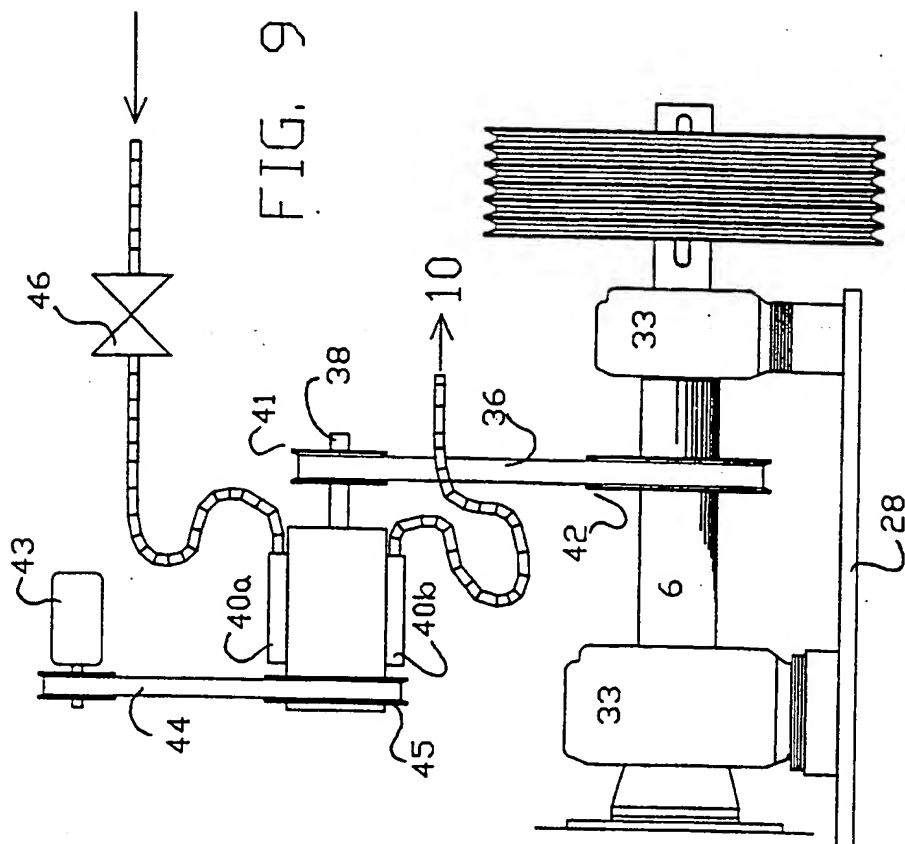


FIG. 6



7/13

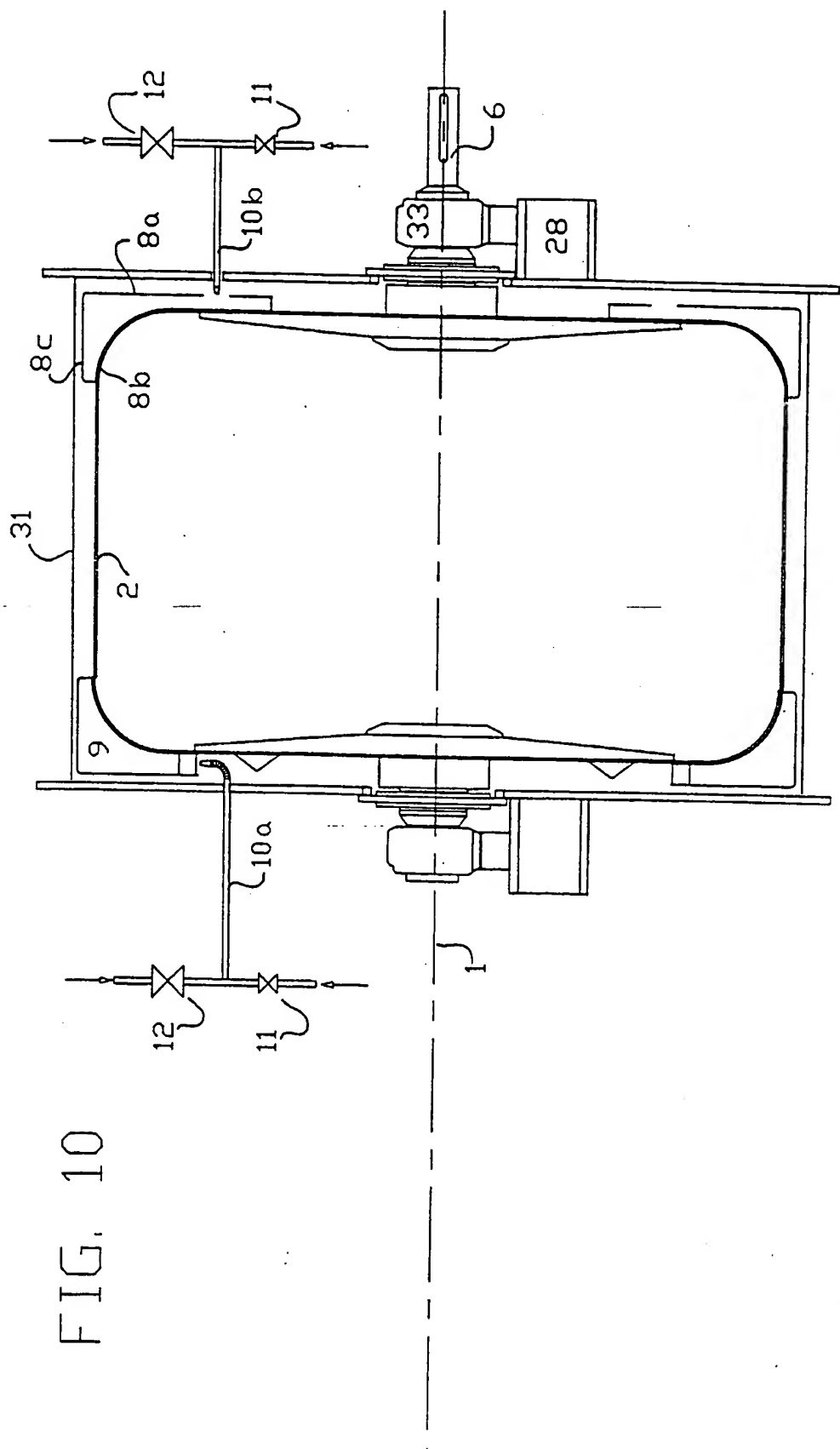


FIG. 10

8/13

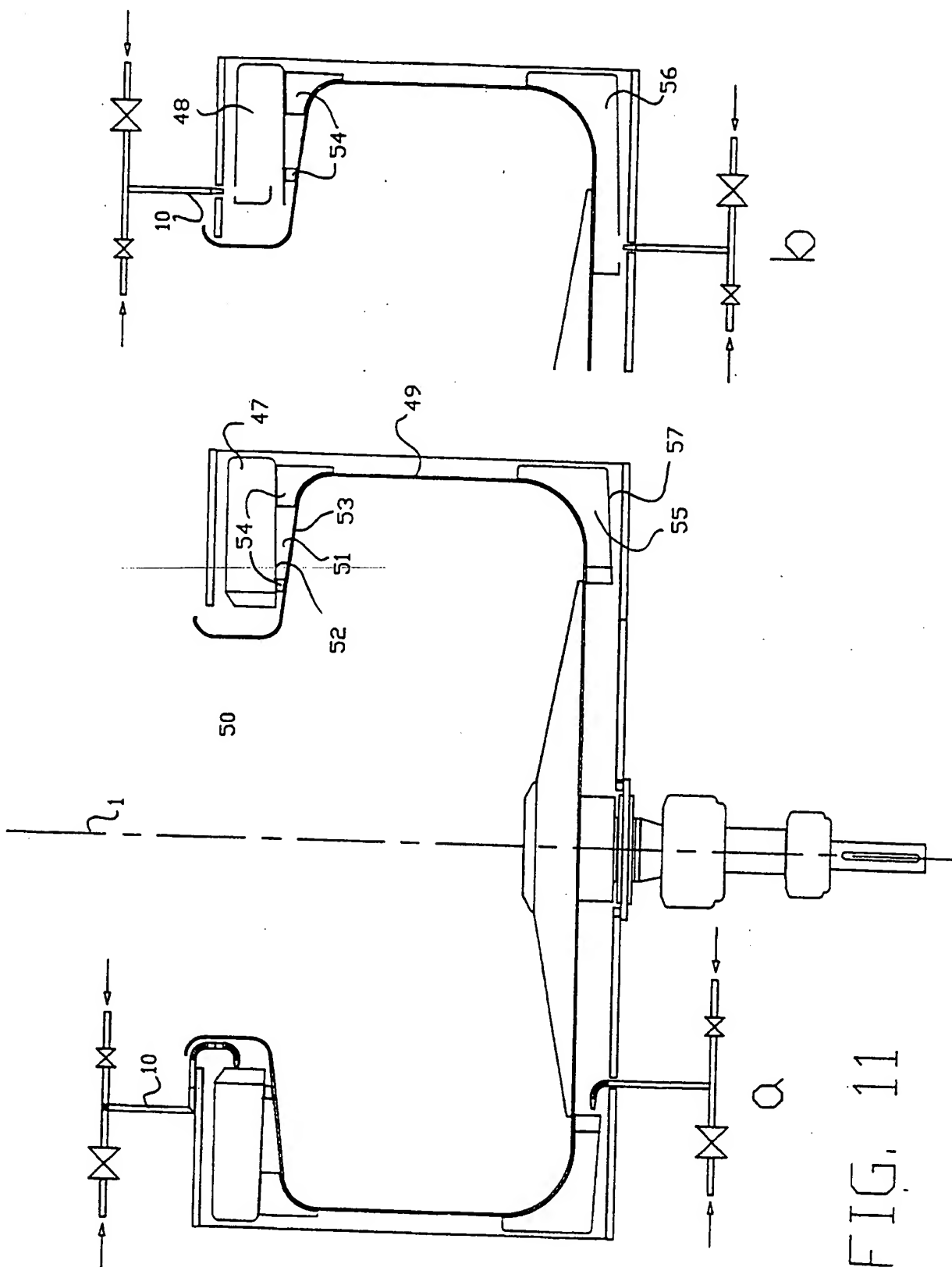
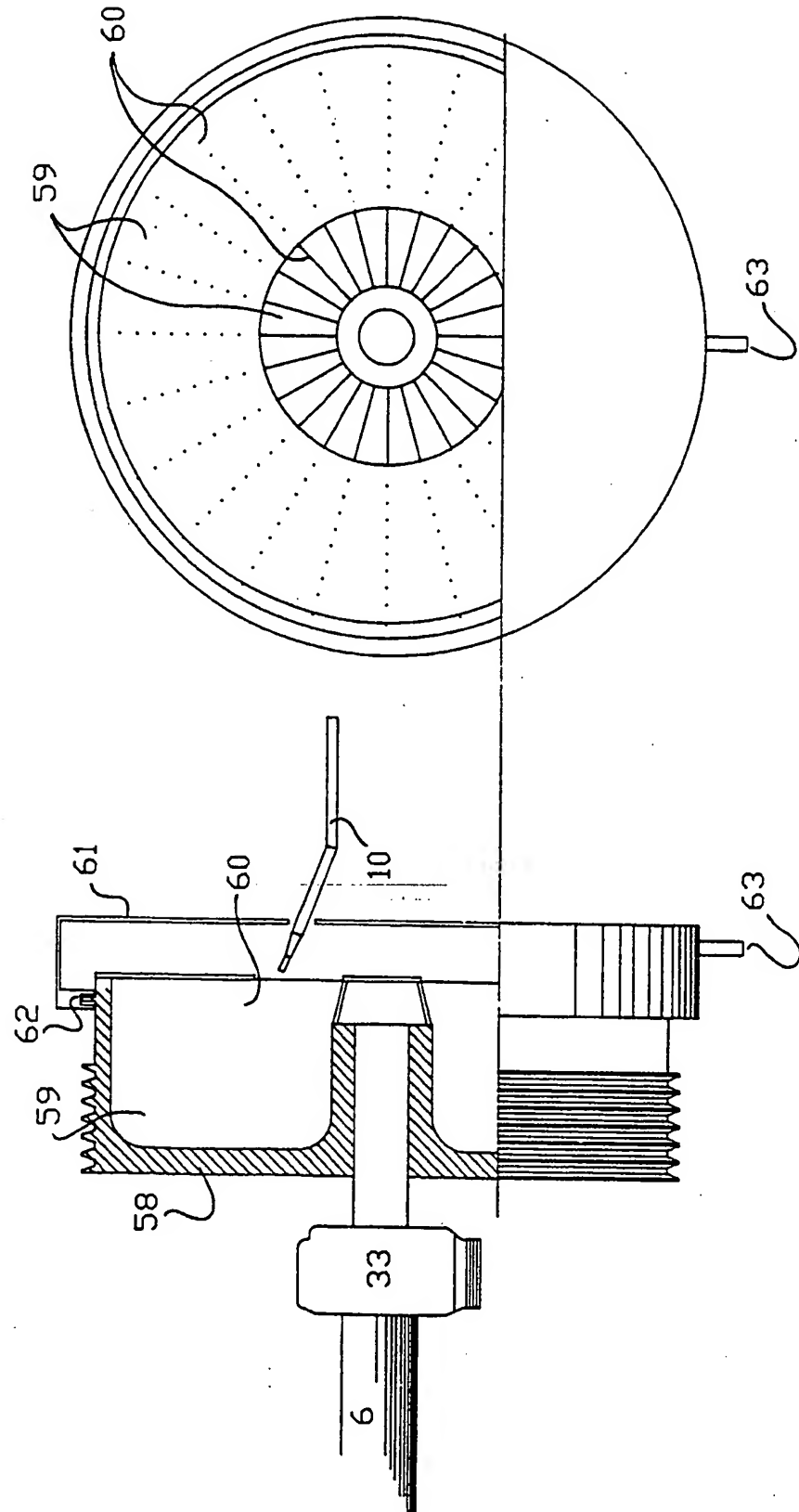


FIG. 11

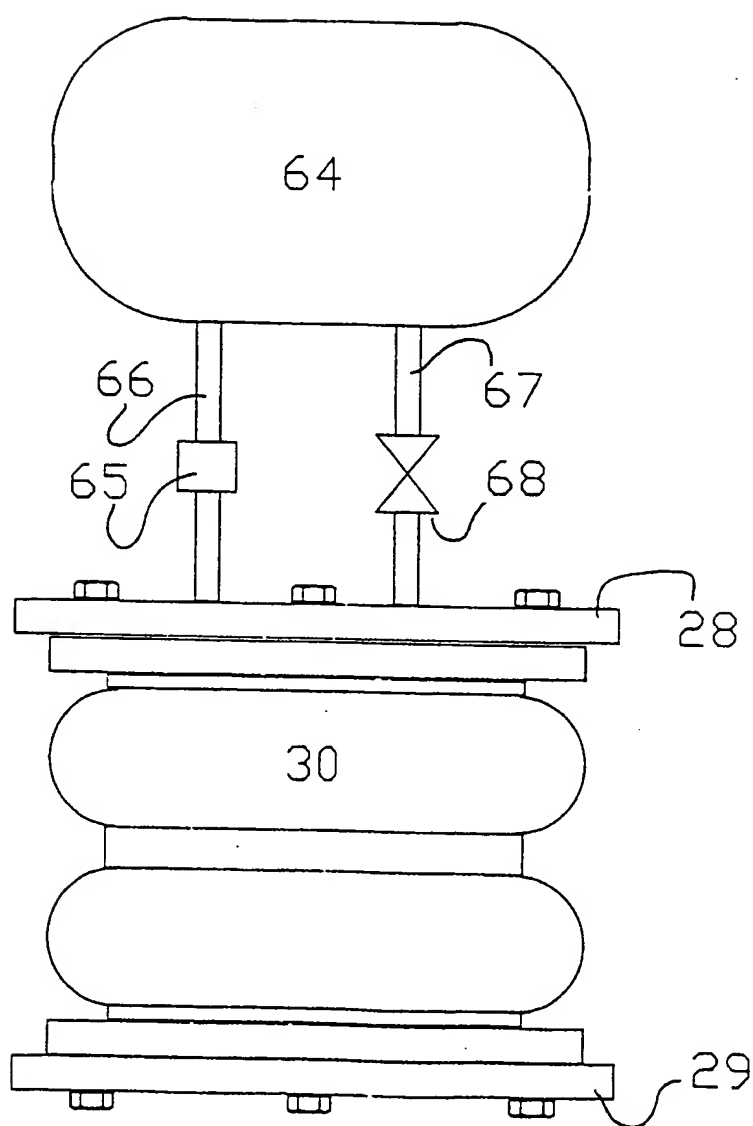
9/13

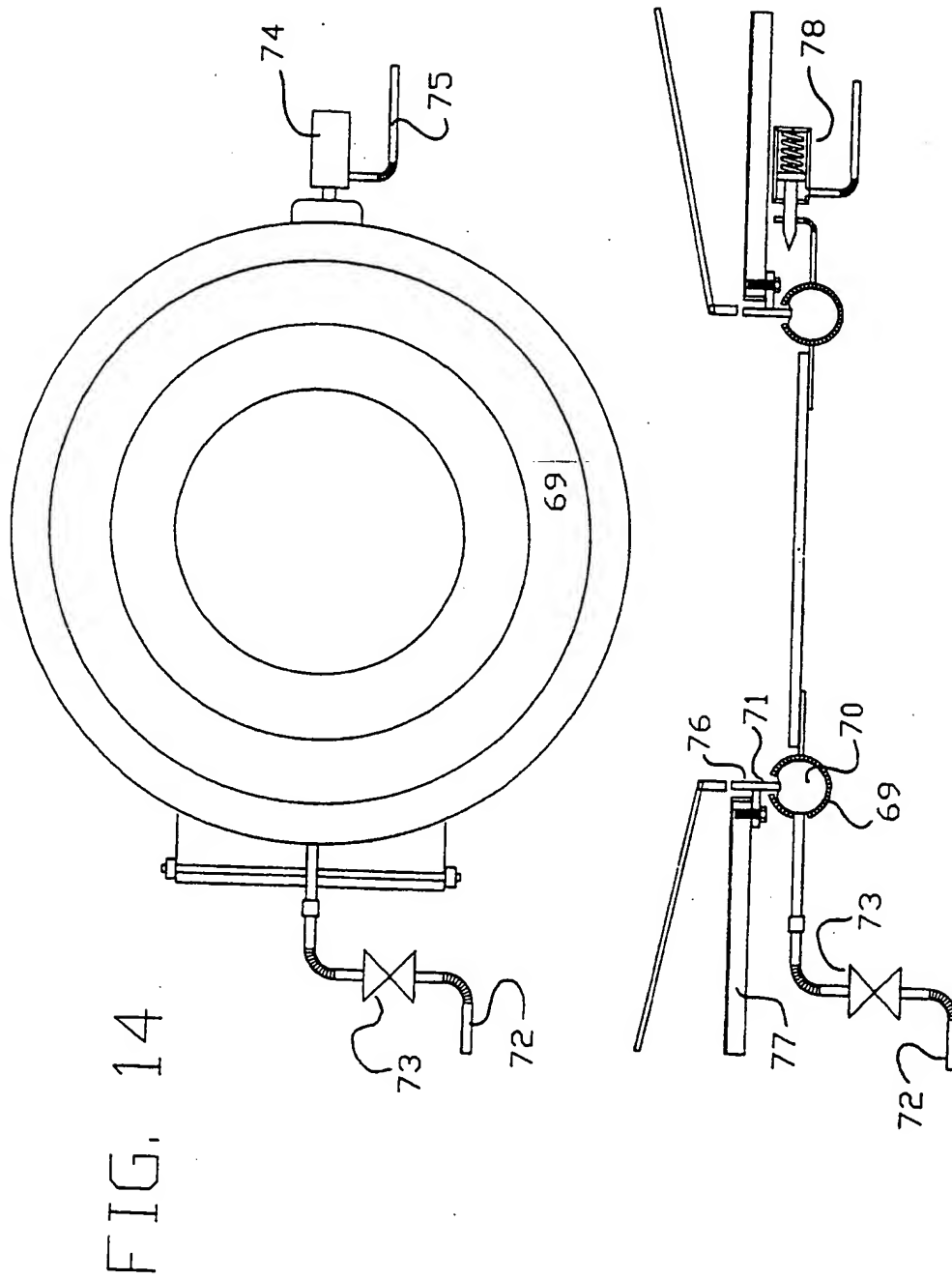
FIG. 12



10/13

FIG. 13





12/13

FIG. 15 FIG. 16

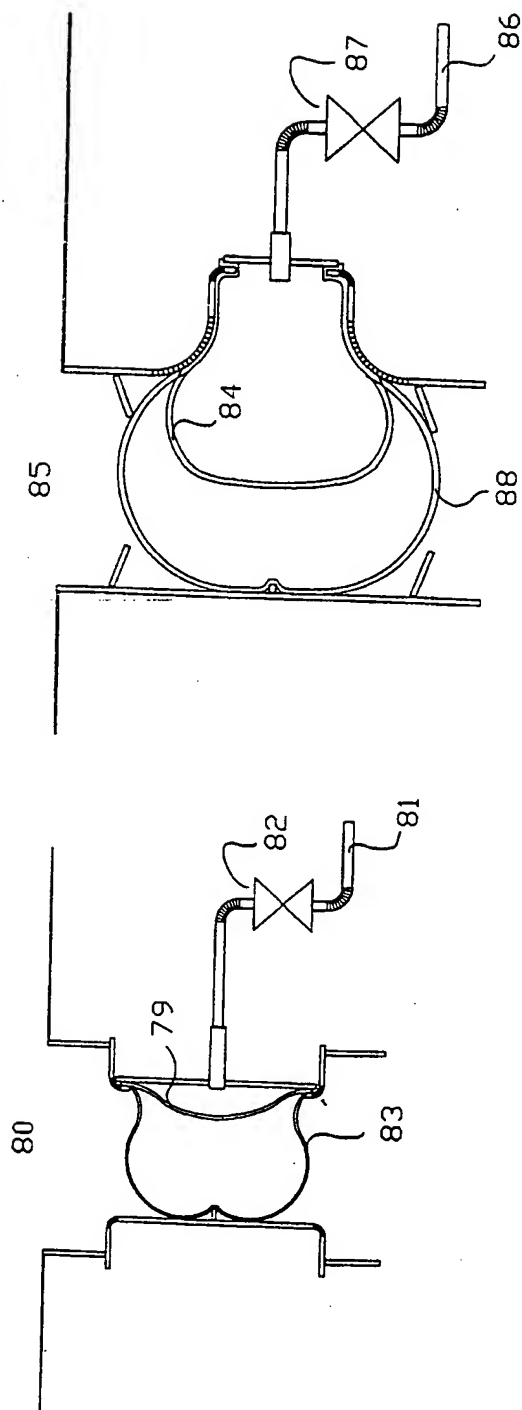
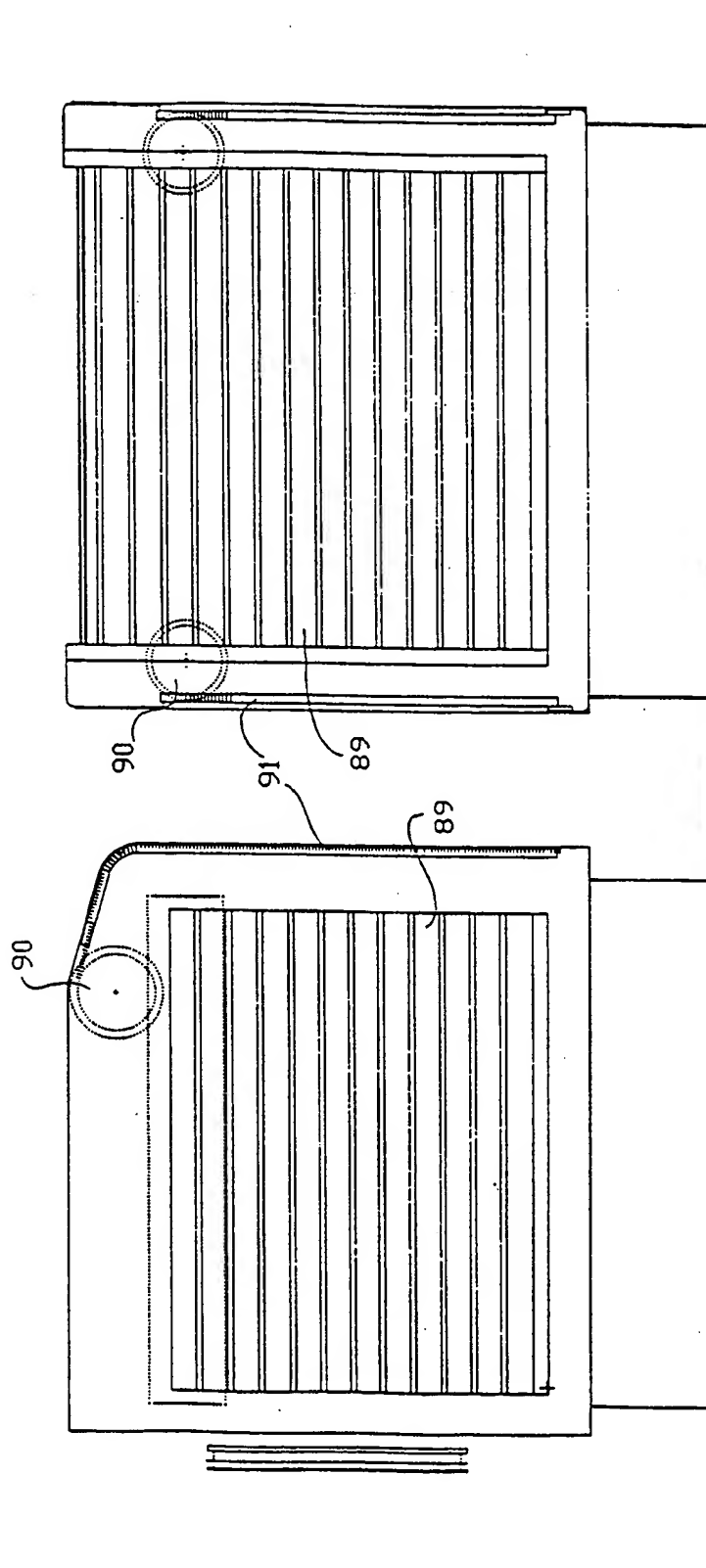


FIG. 17



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(30) Priority Data:
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2038/3 Sokak No. 36, Atakent Bostanlı, 35540 İzmir (TR).

(72) Inventor; and

(75) Inventor/Applicant (for US only): KAZAZOGLU, Hüseyin,
Sinan [TR/TR]; 2038/3 Sokak No. 21, Atakent Bostanlı,
35540 İzmir (TR).

(74) Agent: ANKARA PATENT BUREAU LTD.; Schit Adem
Yavuz Sokak 8/22, 06440 Kizilay Ankara (TR).

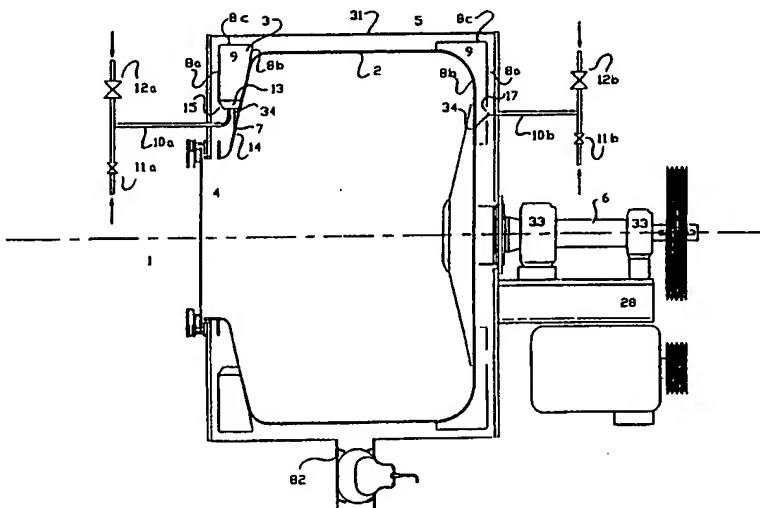
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(54) Title: SMART BALANCING SYSTEM



(57) Abstract

This invention is related to a smart balancing system, where it determines the steady or varying imbalance force vectors acting on rotational drum (2) or rotors, while rotating at high speeds and counterbalances the said imbalance force vectors by using one or more "balancing drums" (3) fitted onto the same drum or rotor along the same rotational axis and one of the areas where such a balancing system used, being high speed spinning washing machines, where the imbalance force vectors acting on the system while spinning at high speeds are eliminated by the use of said intelligent balancing system.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/TR 99/00018

A. CLASSIFICATION OF SUBJECT MATTER

IPC⁶: D 06 F 37/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC⁶: D 06 F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5671494 A (CIVANELLI et al.) 30 September 1997 (30.09.97) fig. 1, 3; abstract.	1-41
A	EP 0704567 A1 (ELECTROLUX) 03 April 1996 (03.04.96) claim 1; fig. 1.	1-41

☐ Further documents are listed in the continuation of Box C.

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Date of the actual completion of the international search

15 December 1999 (15.12.99)

Date of mailing of the international search report

28 December 1999 (28.12.99)

Name and mailing address of the ISA/AT

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/TR 99/00018

The **US 5 671 494 A** describes a method for achieving load balance in washing machines provided with a rotary drum driven by an electric motor under the control of control means, and in which a circuit is provided for measuring a physical quantity associated with information relative to the state, balanced or unbalanced, of the load in the drum, the method comprising gradually increasing the drum speed from a wash speed toward an orbital speed during a stage in which the physical quantity is continuously monitored to ascertain the state of load distribution within the drum, and or accelerating the drum during a stage of maximum acceleration causing an instantaneous rotational speed increase up to a first high speed, to hereby orbit the load, at the moment in which a state of balanced load distribution with the drum is detected.

The **EP 704 567 A1** discloses a clothes washing machine provided with a washing tub, a drum adapted to rotate inside said tub and to hold the washload, a motor capable of driving said drum at a number of variable rotating speeds, and an arrangement adapted to detect an unbalance condition of the washload, adapted to perform a spin-extraction phase comprising a sequence of drum revolutions under low-speed spinning conditions so as to favour a balanced distribution of the washload in the drum, wherein after such a distribution of the washload within a predetermined balancing level a second spin-extraction phase is started at an intermediate spinning speed for a very short period of time.

After this second spinning phase, the speed of rotation of the drum is reduced to the low-speed spinning value so as to keep the distributed washload adhering against the walls of the drum. Thereupon, the drum speed is again increased up to said intermediate spinning speed, which is then maintained for a given period of time.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/TR 99/00018

Patent document cited in search report			Publication date	Patent family member(s)		Publication date
US	A	5671494	30-09-1997	IT	A0 942600	21-12-1994
				IT	A1 942600	21-06-1996
				IT	A 1271782	09-06-1997
EP	A1	704567	03-04-1996	DE	C0 69508510	29-04-1999
	B1	704567	24-03-1999	DE	T2 69508510	23-09-1999
EP	B1	704567		ES	T3 2132474	16-08-1999
				IT	A0 940057	28-09-1994
				IT	B1 1267586	07-02-1997
				JP	A2 8112487	07-05-1996

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